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Research Note

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COMPARISON OF PERCENT SHRINKAGE AND SPECIFIC GRAVITY FOR THREE TYPES OF WESTERN WHITE PINE WOOD

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ABSTRACT

Live, dead down, and dead standing western white pine trees were sampled in north Idaho for the purpose of comparing the physical properties of live and dead trees. Twelve areas were sampled with three trees of each type per area. Volumetric, tangential, and radial shrinkage and specific gravity were the properties measured. No significant difference at the 5 percent level was observed among means of each physical property in the tree types sampled. Some sample areas, however, differed significantly. Mean moisture contents were also calculated for each tree type. The means for live, dead down, and dead standing trees were 73.32, 42.02, and 33.21 percent, respectively.

KEYWORDS: western white pine; dead trees; specific gravity; percent shrinkage.

Western white pine (*Pinus monticola* Dougl.) is one of the most important and valuable timber species of the Northern Rocky Mountains. During the past few years, the mountain pine beetle (*Dendroctonus ponderosae* Hopk.) and the blister rust (*Cronartium ribicola* J.C. Fisch.) have killed a large number of white pine trees in this area. Efforts to salvage and utilize the dead trees have been only partially successful and the volume of dead white pine timber on the Region's National Forests is increasing.

One of the principal uses of white pine lumber has been as door and window frames and sash. For this purpose, dimensional stability is critical. Although the wood from dead trees remains sound and usable for many years after death, lack of information on the specific gravity and shrinkage characteristics of the dead tree wood has deterred its substitution for the green tree lumber normally used by the millwork industry.

The objective of this research was to determine the moisture content, specific gravity, and the radial, tangential, and volumetric shrinkage of specimens cut from dead down and dead standing white pine trees and to compare these values with values obtained from specimens prepared from live trees.

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PROCEDURE

Sampling

Sample material was obtained from 12 harvesting areas scattered throughout the species range. The areas were subjectively selected to provide the largest geographical distribution possible. On each area, three trees of each type--live, dead down, and dead standing--were selected for sampling. The selected trees were free of major decay and had a minimum diameter of 10 inches (25.4 cm) at a height of 32 feet (9.75 m). The diameter requirement insured that sufficient material would be available for test specimens.

The selected trees were felled if necessary, and an 8-inch (20.3 cm) sample section was cut from above the first log (approximately 32 feet [9.75 m]). Sampling at this point minimized the loss of wood. Also, the sample section was probably more representative of the tree than samples taken at the base or the top of the merchantable bole.

Sample sections were immediately labeled, end coated to prevent moisture loss, and placed in plastic bags. The samples were stored in an unheated building until required for the preparation of test specimens.

Preparation of Specimens

Initial breakdown of the sample sections was done on a band saw. Prior to sawing, the 8-inch (20.3 cm) sections were carefully examined to determine the best cutting planes. A cruciform-type cutting pattern was used (fig. 1). The sections were first sawn in two pieces parallel to the grain by removing a 1-inch (2.5 cm) strip containing the pith. Blocks were then cut parallel to the grain from each piece. The blocks were placed in plastic bags and refrigerated until final breakdown, which was done on a table saw.

Test specimens were cut from each block following the procedures outlined in "Standard Methods of Testing Small Clear Specimens of Timber," ASTM D-143-52 (American Society for Testing and Materials 1977). Occasionally, specimens had to be cut from the block slabs because of unexpected knots, decay, or checks encountered in the blocks. Two sets of test specimens, one from each block, were prepared from each tree section. The percent volumetric shrinkage and specific gravity test specimen was 2 by 2 by 6 inches (5.1 by 5.1 by 15.2 cm) and radial and tangential shrinkage specimens were 1 by 4 by 1 inches (2.5 by 10.2 by 2.5 cm) (fig. 1). The initial moisture content of each block was determined using a defect-free piece of the wood and the ovendry test method.

The test specimens were essentially all heartwood. A total of 648 test specimens, 12 areas, 9 trees per area, and 6 specimens per tree were prepared and used.

Testing

The test specimens were first air dried under ambient laboratory conditions. The specimens were weighed and measured at regular intervals during the drying process and individual records were maintained of the dimensional and moisture content changes. Again, procedures outlined in ASTM D143-52 were followed.

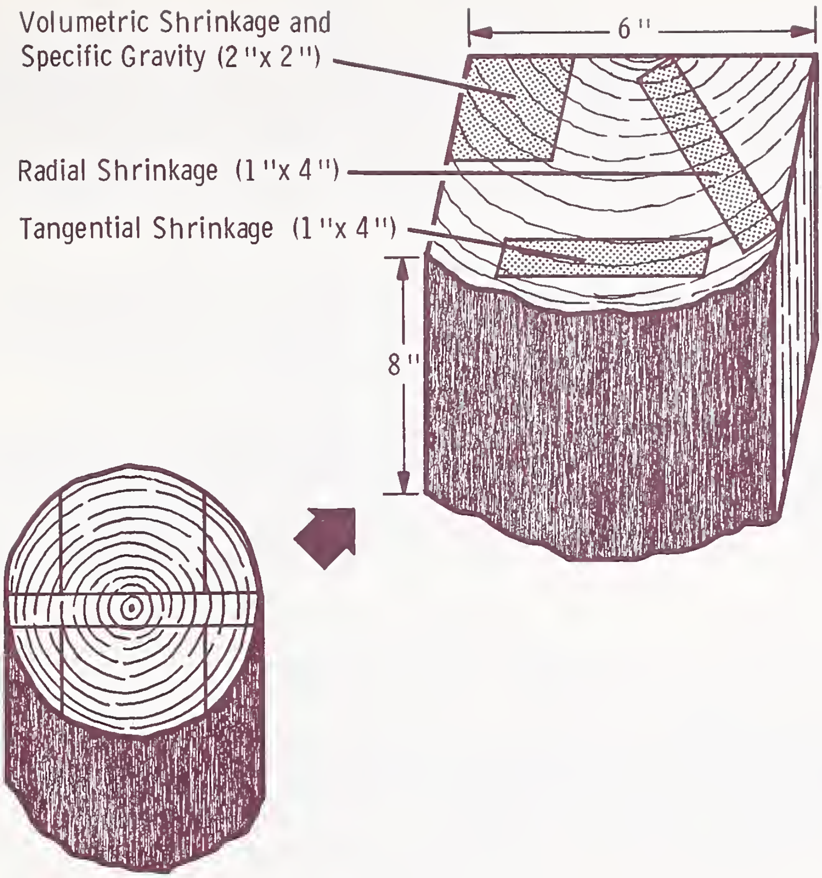
Volumetric Shrinkage and Specific Gravity (2"x 2")
Radial Shrinkage (1"x 4")
Tangential Shrinkage (1"x 4")
6"
8"

Figure 1.--Drawing showing the cutting pattern used with the log sections and the sampling pattern of the test blocks.

The specific gravity-volumetric shrinkage specimens were end coated with paraffin before air drying to reduce the drying rate. The specimens were weighed before and after coating with paraffin so that the weight of paraffin could be deducted in determining moisture content. The paraffin volume was not considered in determining the ovendry volume for the specific gravity determination.

After the test specimens reached equilibrium moisture content in the laboratory, they were ovendried for 24 hours at 212°F (100° C). Final measurements were taken on each specimen after ovendrying. The volumetric shrinkage-specific gravity specimens were recoated with paraffin after the final measurements to prevent absorption of water during volume determination by the immersion method.

Analysis of Data

Shrinkage of wood does not occur until the moisture content is below the fiber saturation point (FSP), which has been defined as that moisture content when the cell walls are saturated and the cell cavities are free from water. Below the FSP the percent shrinkage is essentially linear. Since the FSP is not the same for all species, trees, or specimens, it was necessary to calculate the FSP from the data obtained for each specimen.

A linear regression, computed for each test specimen using a maximum of 25 percent moisture content, was used to calculate the total percent shrinkage and the FSP. Percent moisture content was the independent variable (X axis) and percent shrinkage the dependent variable (Y axis). The intercept values of the X and Y axes were used for FSP and the total percent shrinkage, respectively.

The values obtained for each tree of a specific type--live, dead down, or dead standing--were averaged and compared using covariance analysis, which adjusted for differences in specific gravity and moisture content. The percent shrinkage values, volumetric, radial, and tangential, were compared using this same method. Duncan's multiple range test of the means was used to determine which means differed significantly.

RESULTS AND DISCUSSION

The analyses of covariance showed no significant differences at the 5 percent level among green, dead down, and dead standing trees' shrinkage characteristics and specific gravities. The results of the analyses for each variable are discussed separately.

Volumetric Shrinkage

By area, the volumetric shrinkage means, adjusted for percent moisture content and specific gravity, ranged from 8.81 to 11.79 percent.

The percent volumetric shrinkage from green to ovendry for western white pine is 11.8 (USDA 1974). The experimental value for all tree types and areas combined is 10.22 percent, fairly close to the published value.

There were no significant differences among the means of the tree type, but there were significant differences among the means of the 12 areas.

Tangential Shrinkage

The tangential shrinkage means adjusted for moisture content and specific gravity by tree type ranged from 6.68 to 8.23 percent and by area ranged from 6.97 to 7.85 percent. There were no significant differences between the means for tree conditions or for the area means.

Tangential shrinkage from green to ovendry is 7.4 percent (USDA 1974). The experimental value was 7.5 percent.

Radial Shrinkage

The covariance analysis of the radial shrinkage showed no significant differences among the sample areas. The overall radial percent shrinkage means adjusted for moisture content and specific gravity by tree conditions were: live 3.49; dead down 3.55; and dead standing 3.37. The mean radial shrinkage by area ranged from 3.07 to 3.83 percent.

The percent radial shrinkage from green to ovendry for western white pine is 4.1 percent (USDA 1974) and the overall study value was 4.5 percent.

Specific Gravity

All specific gravity determinations were based on green volume and ovendry weight.

There were highly significant differences in the mean specific gravity by sample area, but no significant difference among the tree types. The specific gravity area means ranged from 0.321 to 0.366 and the specific gravity tree type means were live 0.346, dead down 0.343, and dead standing 0.332. The overall mean specific gravity was 0.340 and the published value for the species is 0.35 (USDA 1974).

Moisture Content

The overall mean moisture content for live trees was 73.32 and the area means ranged from 59.23 to 96.22 percent. The dead down trees had a mean moisture content of 42.02 and a range of from 26.85 to 73.12 percent. The overall mean percent moisture content for the dead standing trees was 33.21 percent and the range was from 15.38 to 67.21 percent. The sequence of the moisture content means for the three tree types (conditions) was not surprising. Drying had reduced the percent moisture content of the dead trees to approximately half the moisture content of the live trees. The dead down trees had either absorbed moisture from the soil or were more protected by the underbrush than the dead standing trees and so were at a slightly higher moisture content level.

SUMMARY

No significant differences were found among the shrinkage characteristics and specific gravity for live, dead down, and dead standing western white pine trees. Specific gravity and volumetric shrinkage means showed highly significant differences among the 12 sample areas; there were significant differences among the radial shrinkage means by area; and the tangential shrinkage means showed no significant differences among the sample areas.

A reasonably consistent pattern of shrinkage properties is apparent among areas, if one shrinkage value is low, other values tend to be low and if one shrinkage value is high, other values tend to be high (fig. 2). This relationship was not statistically evaluated, but could be attributed to area differences.

The differences between areas can be attributed to a number of factors including elevation, aspect, soil type, genetics, microclimatic, growth conditions, and stand conditions. None of these variables were measured during the sample collection period.

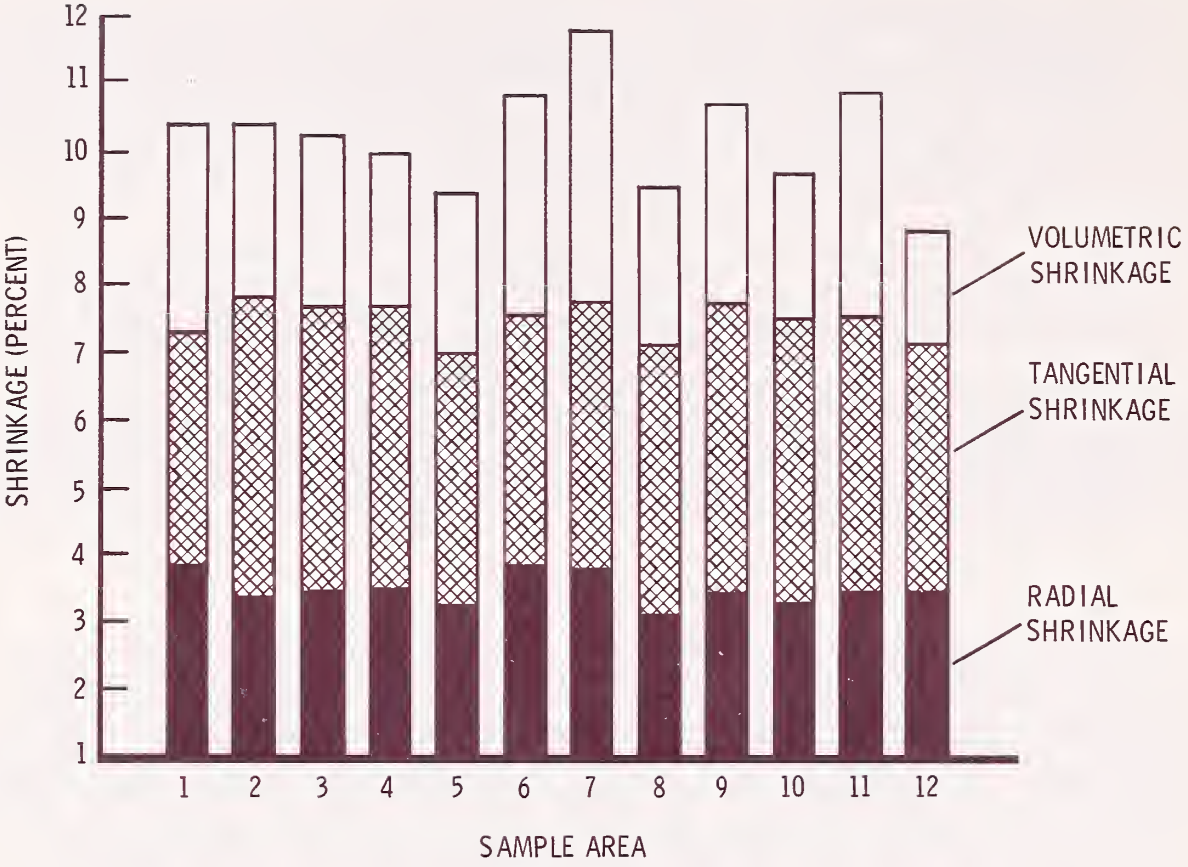

Figure 2.--The adjusted average percent volumetric, tangential, and radial shrinkage by area.

CONCLUSIONS

The results of this study indicate that the dimensional stability of lumber produced from dead western white pine trees is essentially the same as lumber produced from green or live trees. There were no statistically significant differences in the volumetric, tangential, or radial shrinkage values for the live, dead down, and dead standing trees. The mean shrinkage values observed were essentially the same as the published values for the species.

There were significant differences among mean shrinkage values for the areas sampled. The sample trees were selected on areas being harvested that were distributed throughout the range of the species and represent a wide variety of growth and stand conditions. Although no detailed field data were obtained from the 12 areas sampled, the significant differences among areas can probably be attributed to the site and growth conditions of the sample trees.

Specific gravity varied significantly among the areas sampled. These differences, too, were probably due to the location and growth conditions of the sample trees.

As would be expected, the live trees had the greatest average moisture content, 73.3 percent, and the dead standing trees the lowest, 33.2 percent. The average moisture content of the dead down trees was 42.0 percent. The lower moisture content of the dead trees indicates a shorter drying time would be needed in processing lumber from dead trees.

This study indicates that western white pine lumber made from dead trees is not different in shrinkage values or specific gravity from green tree lumber and should be suitable for manufacture into the same products.

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